

## Patent claims

- 5 1. Multilayer structure (10, 20; 30; 40) for packaging, having a bending resistance/ rigidity of at least 100 mN (as measured by SCAN-P 29:35), at least comprising an intermediate layer of an expanded polymer (11; 21; 31; 41) and on each side of said expanded polymer layer, a gas barrier layer (12,13; 22,23; 34,35; 42,43), the material of the gas barrier layer having an oxygen gas permeability of at most about  $2000 \text{ cm}^3/\text{m}^2$  at 23 °C and 0 % RH, per 1  $\mu\text{m}$  thickness, during 24 h, at 1 atm.
- 10 2. Multilayer structure for packaging according to any one of the preceding claims, characterised in that the outermost layers (14,15; 22,23; 46,47) comprise a heat sealable thermoplastic polymer.
- 15 3. Multilayer structure for packaging, according to any one of the preceding claims, characterised in that said expanded polymer layer (11; 21; 31; 41) in its cells and/or open cavities is filled with an anaerobic gas or has a lower partial pressure of oxygen.
- 20 4. Multilayer structure for packaging, according to any one of the preceding claims, characterised in that the expanded polymer has at least about 500 cells/ $\text{mm}^3$ , preferably at least about 1000 cells/ $\text{mm}^3$ .
- 25 5. Multilayer structure for packaging, according to any one of the preceding claims, characterised in that said expanded polymer layer (11; 21; 31; 41) has cells, which are substantially closed without connection between the cellular cavities.
- 30 6. Multilayer structure for packaging, according to any one of the preceding claims, characterised in that the polymer material in said expanded polymer (11; 21; 31; 41) layer also is a polymer having gas barrier properties.

7. Multilayer structure for packaging, according to claim 6, characterised in that the polymer material of the expanded polymer has an oxygen gas permeability of at most about  $1000 \text{ cm}^3/\text{m}^2$  at  $23^\circ\text{C}$  and  $0\% \text{ RH}$ , per  $1 \mu\text{m}$  thickness, during 24 h, at 1 atm.

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8. Multilayer structure for packaging, according to any one of the preceding claims, characterised in that the expandable polymer material comprises a first rigid component and a second ductile polymer component.

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9. Multilayer structure for packaging, according to claim 8, characterised in that the first rigid polymer component is selected from the group essentially comprising a high density polyethylene and high melt-strength polypropylene and that the second, ductile polymer component has been selected from the group essentially comprising low density polyethylene and a general-purpose grade of polypropylene.

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10. Multilayer structure for packaging, according to any one of claims 8 or 9, characterised in that the mixing ratio of the first, rigid polymer component to the second, ductile polymer component in the expanded polymer layer is between 1:3 and 3:1, preferably from about 1.25:1 to about 1.5:1.

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11. Multilayer structure for packaging, according to any one of the preceding claims, characterised in that said gas barrier layer (12,13; 22,23; 34,35; 42,43) comprises a material selected from the group consisting of ethylenevinyl alcohol (EVOH), polyamide (PA), polyvinylidene chloride (PVDC), polyvinyl alcohol (PVOH), polyethylene naphthenate (PEN), polyacrylonitrile (PAN), copolymers from acrylonitrile and butylene, SiOx or carbon plasma coatings ("diamond coatings").

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12. Multilayer structure for packaging, according to any one of the preceding claims, characterised in that it further comprises on each side of the expanded polymer a homogeneous layer (14,15; 22,23; 32,33; 44,45) contributing to the total

rigidity of the multilayer structure, which layer comprises a polymer selected from a group consisting of high density polyethylene (HDPE), polypropylene (PP), polyethyleneterephthalate (PET) and polybutyleneterephthalate (PBT).

- 5 13. Multilayer structure for packaging, according to any one of claims 1-10, characterised in that said gas barrier layers (12,13; 22,23; 34,35; 42,43), on each side of the expanded polymer layer, have a thickness and comprise a material such as to contribute to the total rigidity of the multilayer structure, preferably polyamide (PA), PEN, EVOH, PAN or copolymers from acrylonitrile and butylene, most preferably PA.
- 10 14. Multilayer structure for packaging according to any one of the preceding claims, characterised in that said layers have been laminated to each other in one operation by means of co-extrusion of the layers.
- 15 15. Multilayer structure for packaging according to any one of claims 1-11, characterised in that it comprises on each side of said expanded polymer layer, a paper layer (44, 45).
- 20 16. Multilayer structure for packaging according to any one of the preceding claims, characterised in that the gas barrier layer (12,13; 22,23; 42,43) is directly bonded to the expanded polymer layer (11; 21; 31; 41).
- 25 17. Multilayer structure according to any one of claims 15 or 16, characterised in that the material in said gas barrier layer (42, 43) at least comprises a polymer selected from the group consisting of ethylenevinyl alcohol (EVOH) or polyvinyl alcohol (PVOH).
- 30 18. Multilayer structure according to any one of claims 15-17, characterised in that the gas barrier polymer has been applied onto the paper layers (44, 45) by means of liquid film coating technology.

19. Multilayer structure according to any one of claims 15-18, characterised in that the gas barrier polymer material further comprises a copolymer additive containing functional groups selected from the group consisting essentially of carboxylic acid groups, carboxylic acid anhydride groups, metal salts of carboxylic acids and acetate groups.

20. Multilayer structure according to any one of claims 15-19, characterised in that the gas barrier polymer comprises PVOH and an ethylene acrylic acid copolymer (EAA).

21. Multilayer structure according to any one of claims 15-20, characterised in that the paper layers (44, 45) have a surface weight of between about 20 g/m<sup>2</sup> and about 120 g/m<sup>2</sup>, preferably of between about 30 g/m<sup>2</sup> and about 60 g/m<sup>2</sup>, most preferably of between about 40 g/m<sup>2</sup> and about 60 g/m<sup>2</sup>.

22. Method for manufacturing a multilayer structure according to any one of the preceding claims, at least comprising the steps of mixing (52) a granulate of the expandable polymer material with a chemical, carbon dioxide-generating blowing agent during simultaneous heating (51, 53), for decomposition of the chemical blowing agent and for the formation of a molten plastic mass with homogeneously distributed carbon dioxide blisters; compressing the molten carbon dioxide-containing plastic mass to an excess pressure during simultaneous cooling (54) for converting the carbon dioxide blisters into an overcritical state, and forcing the compressed, cooled plastic melt through a nozzle aperture (55, 56) during simultaneous expansion of the overcritical carbon dioxide blisters for the formation of the expanded polymer layer.

23. Method according to claim 22, characterised in that the chemical, carbon dioxide-generating blowing agent is selected from the group essentially comprising sodium hydrocarbonate, citric acid and mixtures thereof, and that the quantity of blowing agent is approximately 0.5-2.5 % of the total weight of the mixture.

24. The method as claimed in any one of claims 22-23, characterised in that the molten, cooled plastic mass is forced through the nozzle aperture (56) at the same time as molten, homogeneous polymer, by a co-extrusion process, is forced through corresponding nozzle apertures for the formation of the surrounding outer layers (12,13,14,15) of the multilayer structure.

25. Method for manufacturing a multilayer structure as defined in any one of claims 15-21, further comprising the steps of coating each of the two paper layers with a gas barrier polymer, advancing said paper layers towards each other, applying and expanding said expandable polymer between said paper layers and laminating the layers to each other.

26. Method for manufacturing a multilayer structure (40) as defined in any one of claims 15-21, further comprising the steps of coating each of the two paper layers (61, 61') with a gas barrier polymer (63,63'), heating the paper layers, advancing said coated paper layers (64,64') towards each other in such a way that the gas-barrier coated sides are facing each other, applying and expanding said expandable polymer (66) between said paper layers and laminating the layers to each other by means of heat fusion.

27. Method for manufacturing a multilayer structure (40) as defined in any one of claims 15-21, at least comprising the steps of coating each of the two paper layers (71,71') with an aqueous dispersion of a gas barrier polymer (73, 73') composition by means of liquid film coating technology (72,72'), subsequently drying (74,74') the coated paper layers at high temperature and advancing them towards each other in such a way that the gas-barrier coated sides are facing each other (75,75'), laminating the paper layers to each other while still hot by simultaneously applying and expanding said expandable polymer material (77) between them.

28. Method for manufacturing a multilayer structure according to any one of claims 25-27, further comprising the step of coating each of the paper layers (61,61'; 71,71') on its other side with a heat sealable liquid barrier polymer (46,47).

5 29. Dimensionally stable packaging container (80; 90) manufactured from the multilayer structure as defined in any one of claims 1-21.

30. An extrusion-blow moulded container (90) having a multilayer wall structure as defined in any one of claims 1-14 or 16.

10 31. Method for manufacturing an extrusion-blow moulded container (90) according to claim 30, at least comprising the steps of mixing (52) a granulate of the expandable polymer material with a chemical, carbon dioxide-generating blowing agent during simultaneous heating (51, 53), for decomposition of the chemical  
15 blowing agent and for the formation of a molten plastic mass with homogeneously distributed carbon dioxide blisters, compressing the molten carbon dioxide-containing plastic mass to an excess pressure during simultaneous cooling (54) for converting the carbon dioxide blisters into an overcritical state, and forcing the compressed, cooled plastic melt through an annular nozzle aperture (55, 56)  
20 during simultaneous expansion of the overcritical carbon dioxide blisters for the formation of a hose of foamed structure, the forming of the hose of foamed structure taking place at the same time as molten, homogeneous polymer, by a co-extrusion process, is forced through corresponding, annular nozzle apertures (56) for the formation of the surrounding outer layers (12,13,14,15; 22,23) of the  
25 multilayer structure, accomodating the multilayer structured hose in a mould cavity (57) and inflating the hose by means of a high pressure gas against the inner walls of the mould cavity for the formation of the extrusion-blow moulded container (90) having said multilayer wall structure.

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